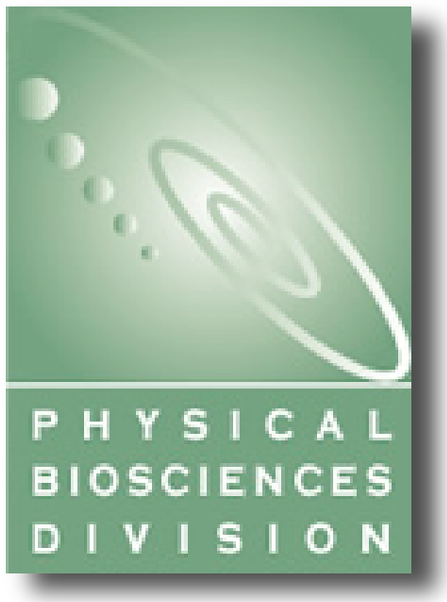
Biological CCS



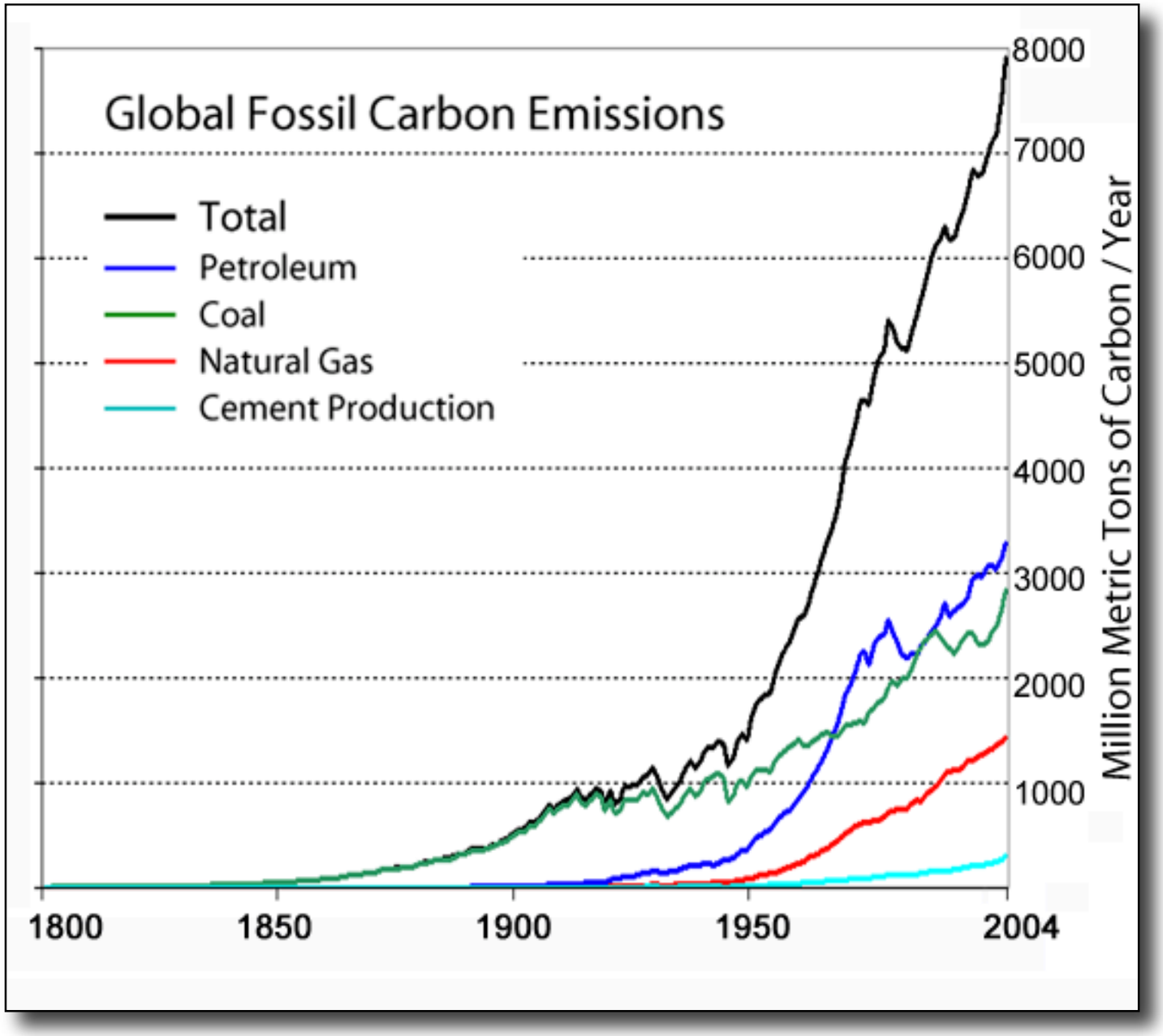
Major greenhouse gases

- water vapor, which contributes 36–72%
- carbon dioxide, which contributes 9–26%
- methane, which contributes 4–9%
- ozone, which contributes 3–7%

From 1750 to 1998, CO_2 increased from 278 to 365 parts per million. Fastest rate of change in Earth's history, by far.

From 1750 to 1998, CH_4 increased from 700 to 1745 parts per billion. Methane traps about 20 times the heat of CO_2.

Radiative forcing:
2/3 CO_2, 1/3 Methane



Some numbers

• The terrestrial carbon cycle provides a sink for about 25% of the anthropogenic carbon emissions that increase atmospheric CO_2.

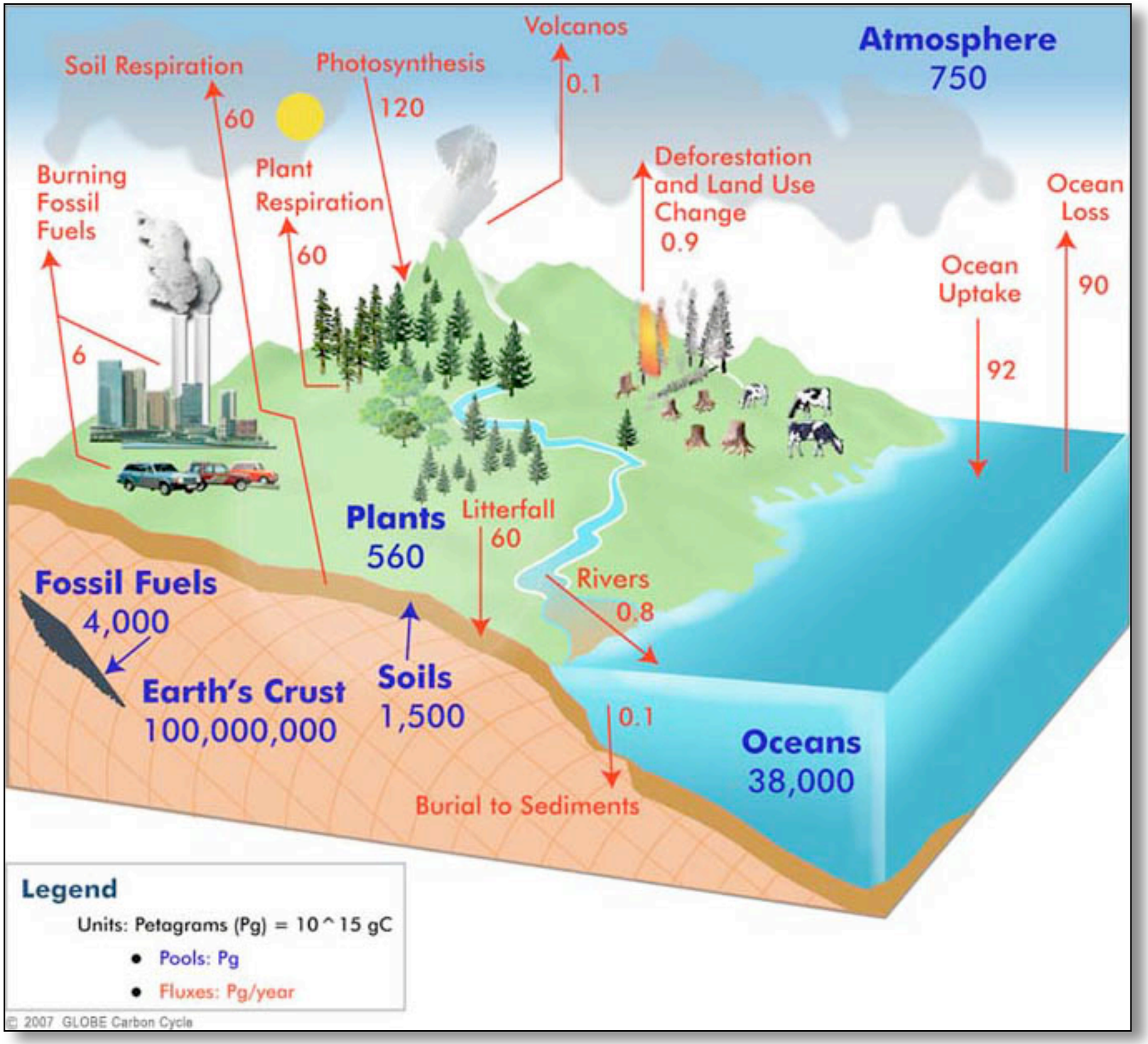
$\Rightarrow$ We already have biological CCS -> biocompatible, free*, global, tested, CO_2 capture system, running at 2 Pg

• 17 million km^2, or 14% of the land surface, has been changed by human agricultural activity. Another 28% is used for domestic animal grazing.

• Every year, new human land-use activities are adding 1 Pg of carbon to the atmosphere, in addition to the 8 Pg per year of fossil fuel carbon emissions. Fraction is likely to increase.

Ecosystem Disturbance, Carbon, and Climate
Science 321, pages 652 - 653 (2008)

Inventory


Volcanos
0.1
Atmosphere
750
Soil Respiration
60
Photosynthesis
120
Deforestation
and Land Use
Change
0.9
Ocean
Loss
90
Burning
Fossil
Fuels
6
Plant
Respiration
60
Ocean
Uptake
92
Plants
560
Litterfall
60
Rivers
0.8
Fossil Fuels
4,000
Earth's Crust
100,000,000
Soils
1,500
0.1
Oceans
38,000
Burial to Sediments
Legend
Units: Petagrams (Pg) = 10^15 gC
Pools: Pg
Fluxes: Pg/year
© 2007 GLOBE Carbon Cycle

Most likely failure mechanisms for global ecosystem

- 40,000 Pg stored in soils, oceans, atmosphere, plants (human flux - 8 Pg)

- Even tiny changes of terrestrial carbon cycle can have enormous consequences

(1) - keep CO_2 and Methane where it is (soil - tundra, ocean) - avoid 'chain reaction' where higher T increase CO_2/Methane release, further increasing T

(2) - keep terrestrial fluxes where they are - prevent sinks flipping to sources. Decomposing forest releases CO_2, rather than capturing it. Release of 1% of ocean CO_2 1/2

(3) - climate capture/sequestration/remediation

* what are fundamental limits to biological capture/sequestration?
* new options for biological capture
* replacing dirty with less-dirty energy sources - avoid sulfur rich coal - microbial oil recovery

Need factors of ten

- looking for factor 10-1000 improvements
- need catalytic, not stoichiometric processes
- biological CCS already has global scale
- biological CCS has potential for extremely low cost*
- over our history, we have improved crop yields by 100-1000x
- imagine dedicated CO_2 fixing plant/microbial community /algae